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BRINGING TO LIGHT A DIURNAL VARIATION OF THE ENERGY SPECTRUM OF AURORAL X-RAYS

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SUMMARY

This Note brings forth the results of balloon flights having taken place in Kiruna Sweden during the summers of 1963 and 1964. It is shown than the average energy of auroral X-rays increases between 01 00 and 17 00 hours local time and decreases rapidly after 22 00 hours local time.

It would seem that this variation is mainly due to a corresponding variation of the energy of auroral electrons.

Author

* * *

The energy of the electrons precipitated in the aurora zone have been frequently measured onboard rockets and satellites. A recapitulation of the results was given by Hultquist [1]. The energy spectra show a great divergence which may be due, one one hand to the complexity of the phenomena and to the short duration of measurements aboard spacecrafts crossing the auroral zone on the other.

Balloons allow long-range observations at specified positions. Unfortunately, this method has the disadvantage of being indirect: only bremmstrahlung X-rays can be detected.

It is not possible to obtain the intensity of the energy spectrum of electrons at atmosphere summit starting from X-rays at balloon level; however, any intensity variation or any variation of the energy spectrum

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* Mise en évidence d'une variation diurne du spectre d'énergie des rayons X d'origine aurorale.

of X-rays will generally reflect a similar variation of electrons of auroral origin.

The result presented here has been obtained after registrations of balloon flights in the course of a campaign during the summers of 1963 and 1964 in Kiruna (Sweden) [2], this being a joint operation by the groups of the Max Planck Institut für Aeronomie (Lindau/Hartz) and of the "Laboratoire de Physique Cosmique (Meudon), within the framework of the S.P.A.R.M.O program.

The detectors were of standard "Sparmo" type [3]. They included one counter of aluminum walls and one of bismuth walls, designed for the measurement of X-rays.

The efficiency of the two counters was different for photons of same energy; the energy of X-rays could be determined after the Bi and Al counters' counting rate ratio $R = I(Bi) / I(Al)$.

The relationship of this ratio (R) with the energy is not known with great precision, but provides a good indication. In the case when the registered photons are monoenergetic, R corresponds to the values compiled in Table 1:

TABLE 1

R	E (keV)	γ
0.5	30	1.5
1.0	40	0.5
1.5	50	0.0

In reality, the detected X-rays are not monoenergetic; R then becomes a measure of mean energy. If the X-ray spectrum is of the form

$$dn = E^{-\gamma} . dE \quad (20\,keV < E < 200\,keV),$$

R corresponds to the values of γ given in Table 1 above.

The curves 1 of Fig. 1 (next page) are representative of the counting rate of the Al counter in the course of the two flights as a function of local time. The curves 2 represent the ratio R of observed auroral X-rays by 5 min. intervals.

It may be seen, that the ratio R, that is, the mean energy, increases after midnight from one event to the other. One of the two flights offers

two X-ray events before midnight. For the first of them, the mean energy is high and it decreases for the second event.

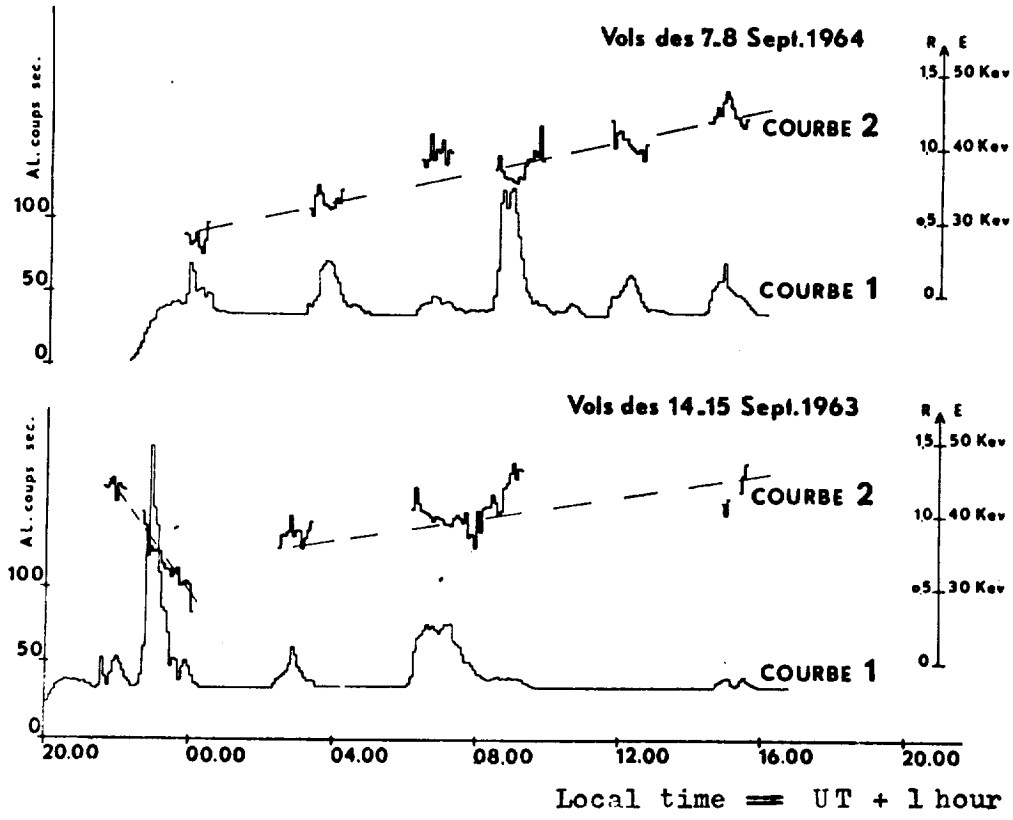

Fig. 1

The Fig. 2 represents the ratio R of 30 events observed during 13 flights. Only the events observed during balloon ascent and descent have been eliminated. The values of R, of which the statistical error was $>8\%$, were also suppressed.

The distribution of the points confirms the curves 2 shown on Fig. 1. We may notice a minimum of mean energy of X-rays at 01 00 hours local time. This energy subsequently increases gradually until 17 00 hours L.T. The highest energies were observed at about 22 00 — 23 00 hours L.T.

A diurnal variation of the mean energy of X-rays having been ascertained, it is necessary to know whether it has for origin a corresponding variation of the mean energy of electrons.

The absorption coefficient of X-rays in the atmosphere is a function of their energy. The form of the spectrum, thus the mean energy, are influenced by the absorption. An increase in the distance covered by X-rays in the atmosphere would entail a rise of their mean energy and a considerable attenuation of their intensity. Indeed, the spectrum

$$dn = CE^{-2}\,dE \quad (20\,\text{keV} < E < 200\,\text{keV})$$

would give $R = 0.4$, the smallest value observed in the course of our flights. If the spectrum is transformed in such a way that R attain the value of 1.1, the counting rate of the aluminum counter would be diminished by a factor of $I / I_o = 0.08$.

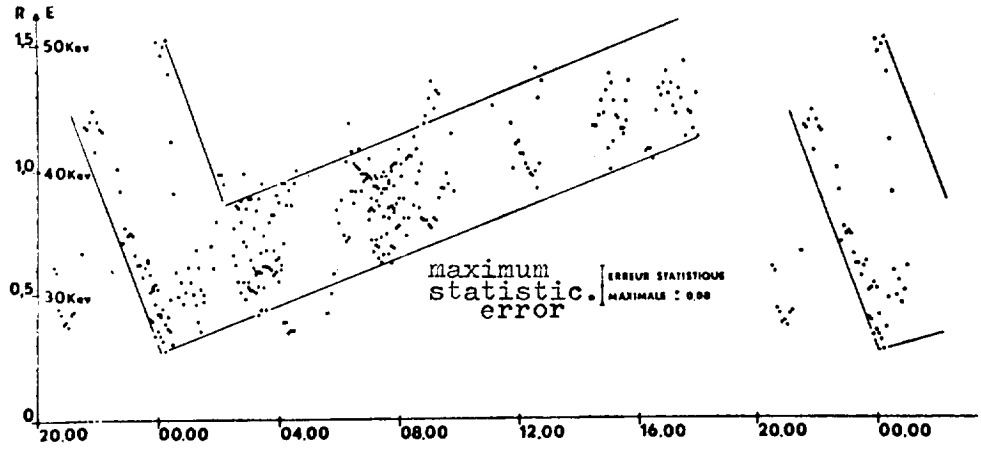

Fig. 2

However, no such decrease is noted : the mean intensity of the events does not vary very much in the course of the day. On the other hand, an increase of the real intensity I_o of the events with local time would be in contradiction with the results obtained by the riometers of numerous stations [4].

The obtained diurnal variation thus seems to be principally due to a corresponding variation of the energy of auroral electrons.

Johansen [5] has studied the relation between the cosmic noise absorption and the luminosity of the aurorae observed at Tromso (Norway). He found a variation of auroral electron energy in the 10 keV band for a limited period of observation from 17 00 to 06 00 hours local time.

A decrease in the energy of these electrons takes place starting at 23 00 hours L.T., followed by a slower rise beginning at 02 00 hours L.T.

Our result between 21 00 and 0600 hours L.T. confirms the Johansen result for a higher energy range (30 to 50 keV); moreover, it shows that the slow rise of electron energy continues till 16 00 hours L.T.

Johansen brought to light a second minimum at 19 00 hours L.T. This result does not contradict ours, for we lack information at that hour of the day : indeed, between 18 00 and 21 00 hours the balloons begin either their descent or ascent. However, we have observed an X-ray event at 21 00 hours local time, of which the weak mean energy might be indicative of the presence of a second minimum.

*** THE END ***

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